



# Femtosecond x-ray beamlines at the ALS

P.A. Heimann

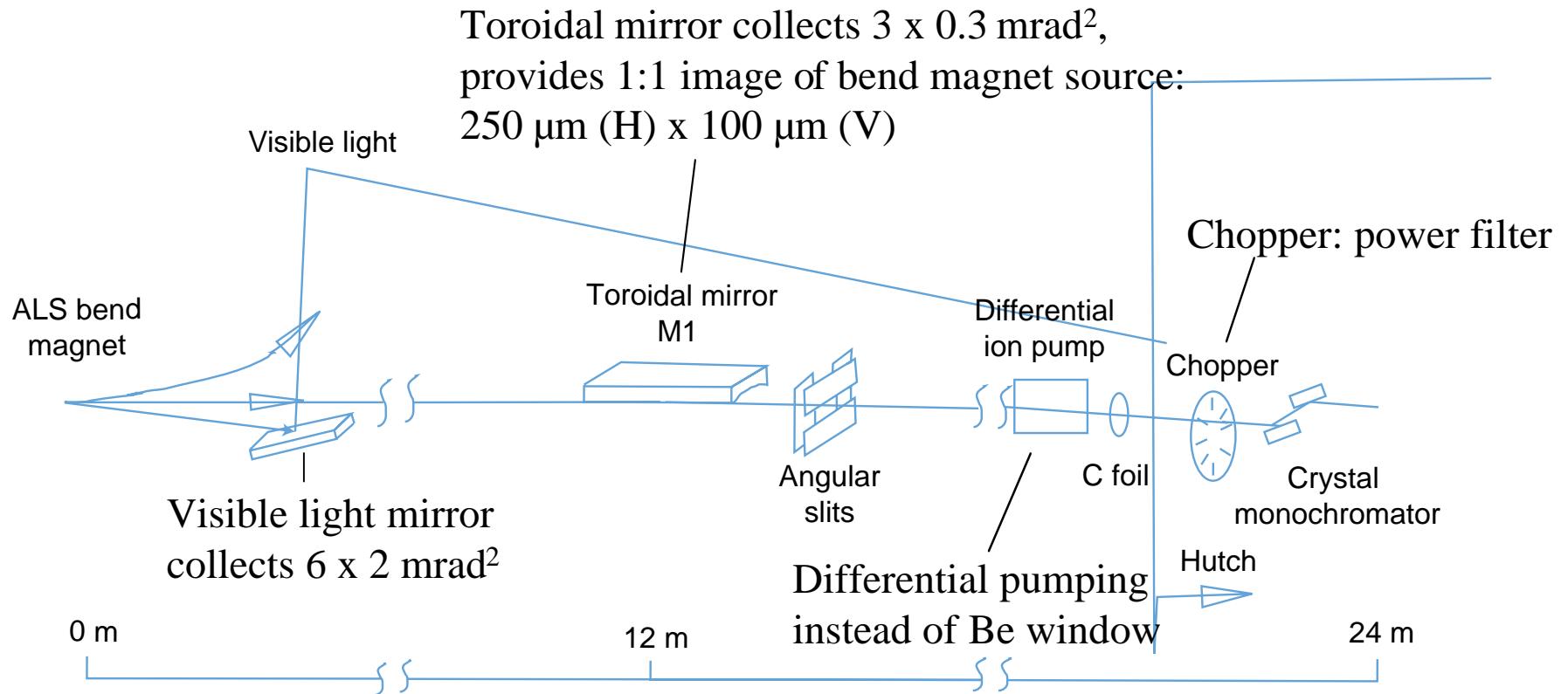
ALS

R.W. Schoenlein, T.E. Glover, H. Chong and H.A. Padmore (LBNL)

A. Lindenberg, S. Johnson, R.W. Falcone (U. C. Berkeley),  
and Z. Chang (U. of Michigan)

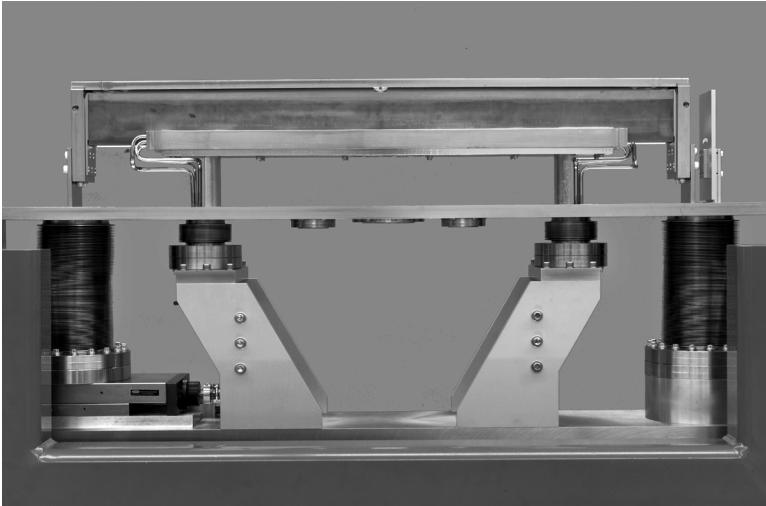
- Bend magnet beamline 5.3.1: recently completed, dedicated to fs laser / x-ray experiments
- Undulator beamline 6.0: proposed UXS facility

# ALS Beamline 5.3.1

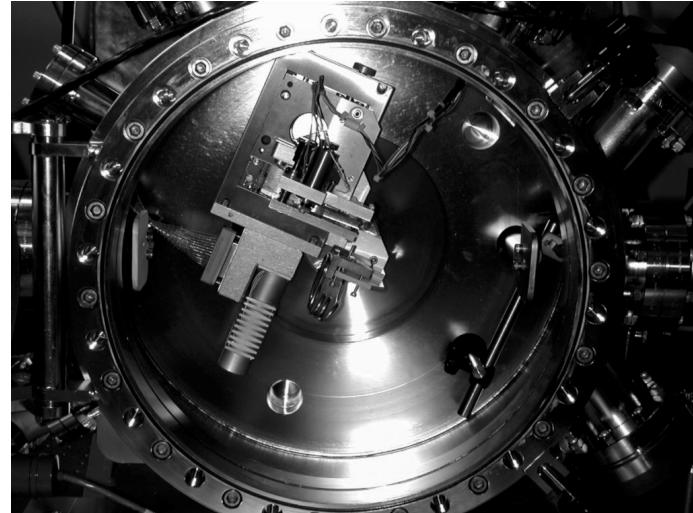


- Beamline completed : end of June
- Commissioning: July - present
- First experiment: September

# Beamline components



M1 mirror, bender, side cooling



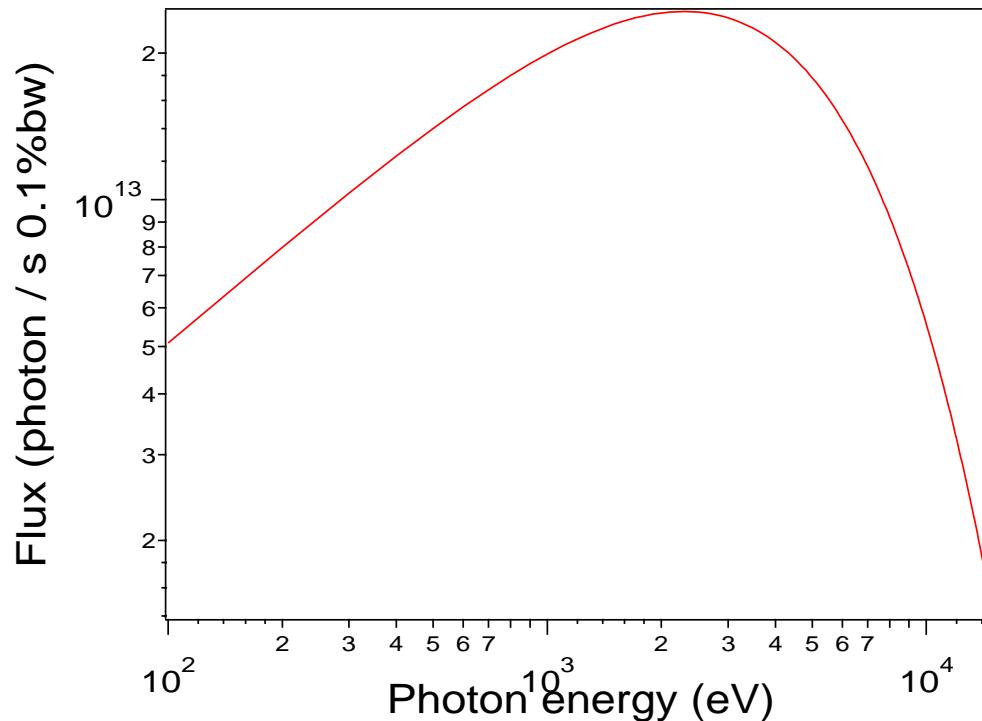
Double crystal  
monochromator: Ge(111),  
Ge(311), InSb(111), Si(111)  
crystals



Chopper: two patterns of slots  
for 1 and 5 kHz repetition rates,  
opening  $\sim 20 \mu\text{s}$

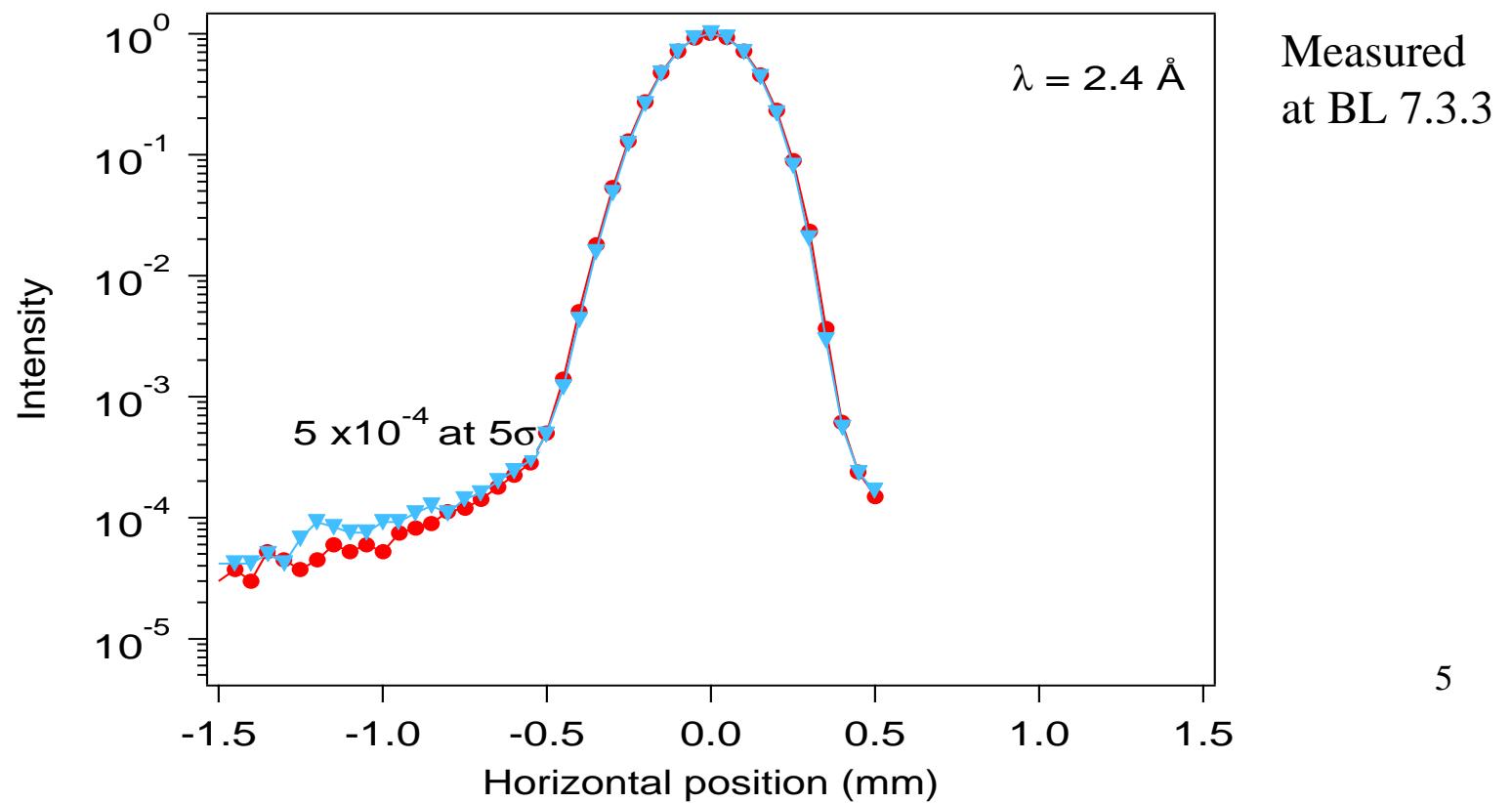
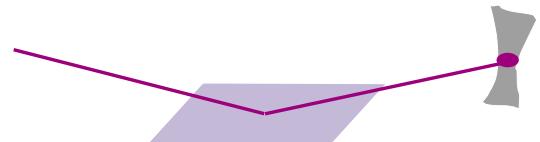
# Wide spectral range of bend magnet source

- Visible light diagnostic: cross correlations with laser pulses as diagnostic of laser-electron beam modulation, accurate relative timing, funded LDRD on coherent far-IR plans test experiment
- Soft x-rays: photoabsorption, photoelectron spectroscopy
- Hard x-rays: diffraction, photoabsorption
- White beam for dispersive detection, Laue diffraction



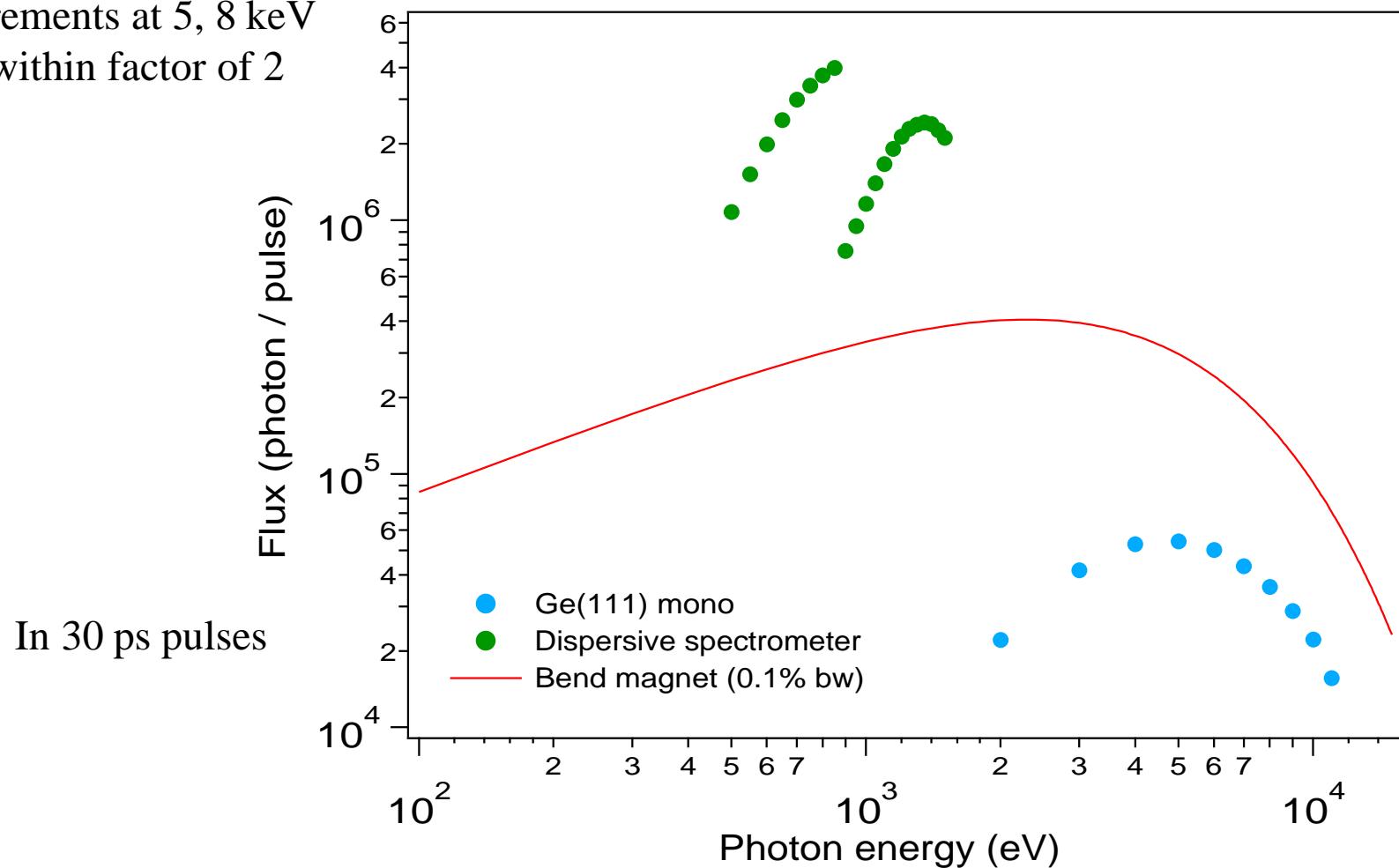
# X-ray scattering

- Scattering critical for signal /background of fs x-ray pulse
- For grazing incidence mirror,  
out-of- plane scattering << in-plane scattering  
(roughness scale  $\sim 5\mu\text{m}$ )    (roughness scale  $\sim 1\text{mm}$ )



## Flux at beamline 5.3.1, calculated

Measurements at 5, 8 keV  
Agree within factor of 2

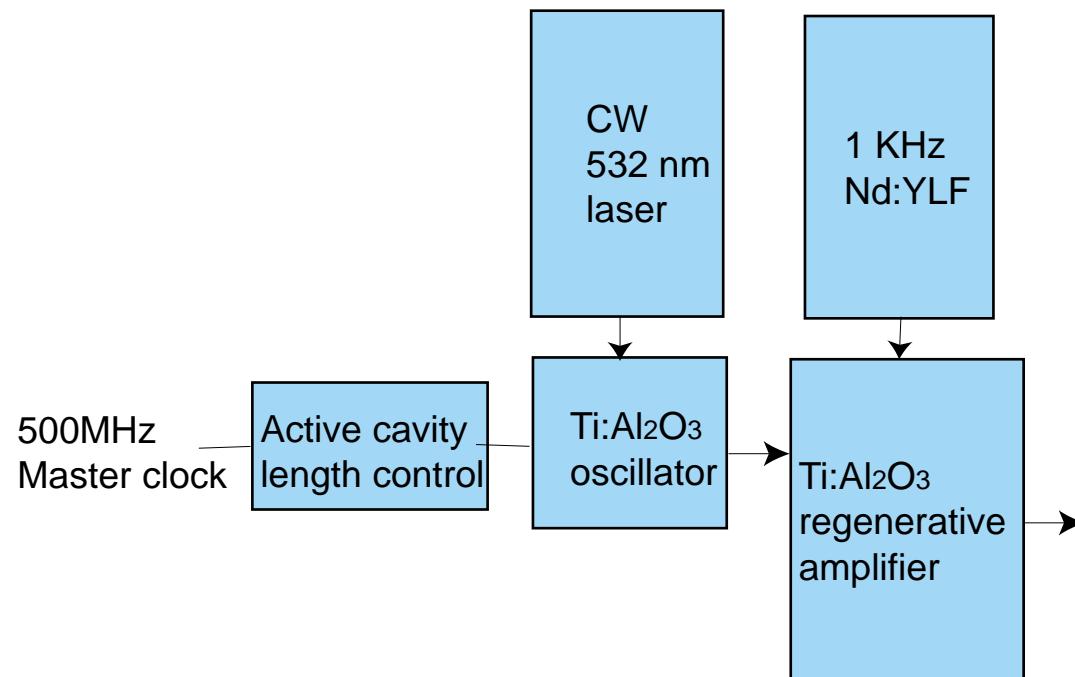


In 30 ps pulses

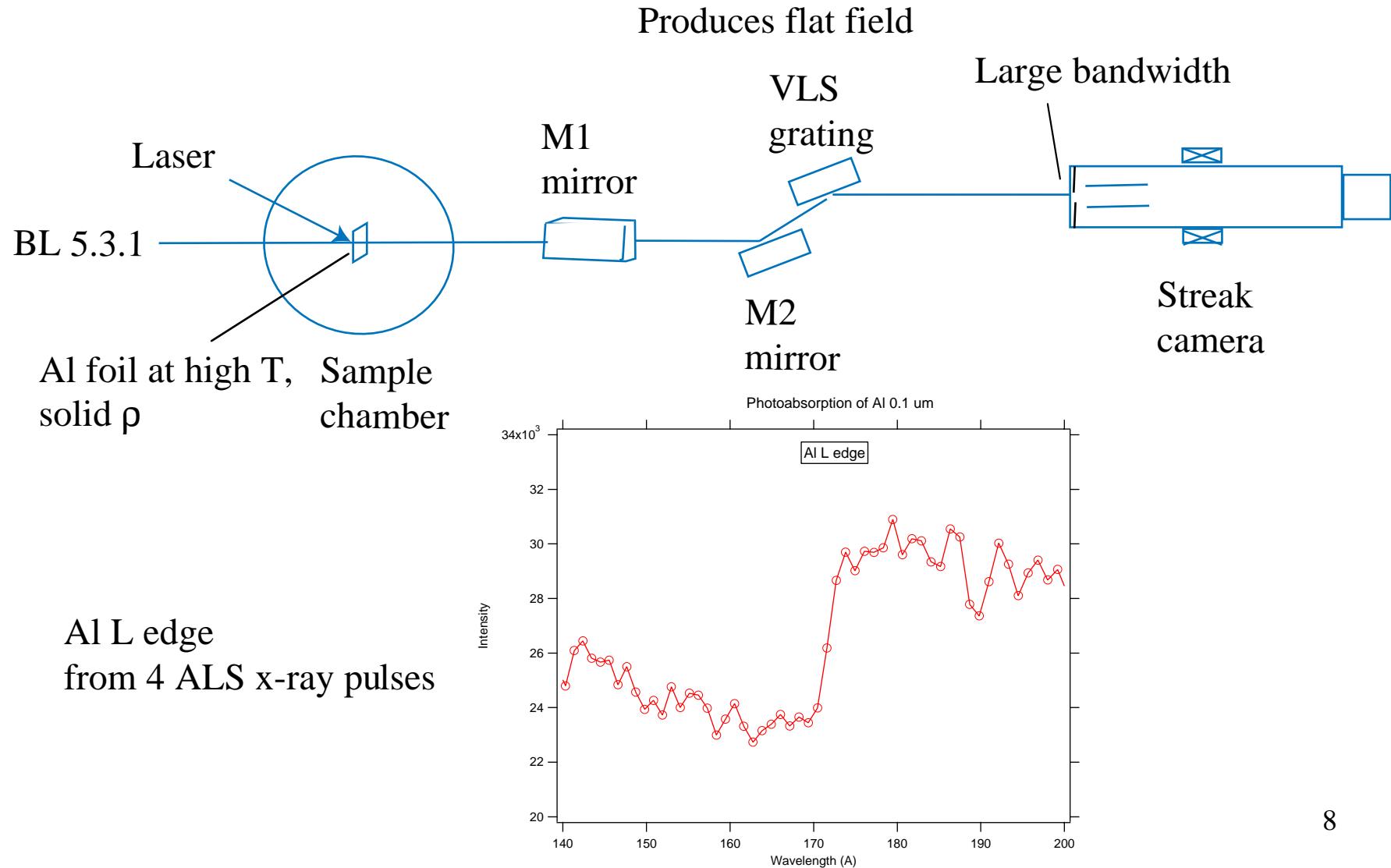
Efficiency factor for fs x-ray pulses  $7 \times 10^{-4}$

## Laser systems at beamline 5.3.1

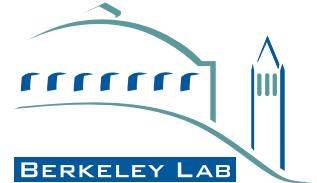
- Positive light Ti:Al<sub>2</sub>O<sub>3</sub> laser system: 800 nm  $\lambda$ , 2 mJ/pulse, 1 KHz, 150 fs (Falcone)
- R. Schoenlein is developing new laser system: 760 nm  $\lambda$ , 1 mJ/pulse, 5 KHz (in resonance with wiggler 3rd harmonic)
- Oscillator synchronized to ALS RF clock: jitter  $\sim$  5 ps
  - At present there is a drift of electron bunches to RF,  $\Delta t \sim 100$  ps will improve by order of magnitude with 312 bunch filling - J. Byrd



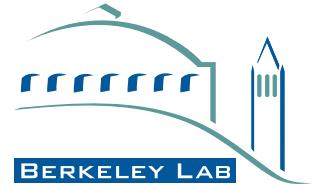
# Dispersive x-ray absorption apparatus



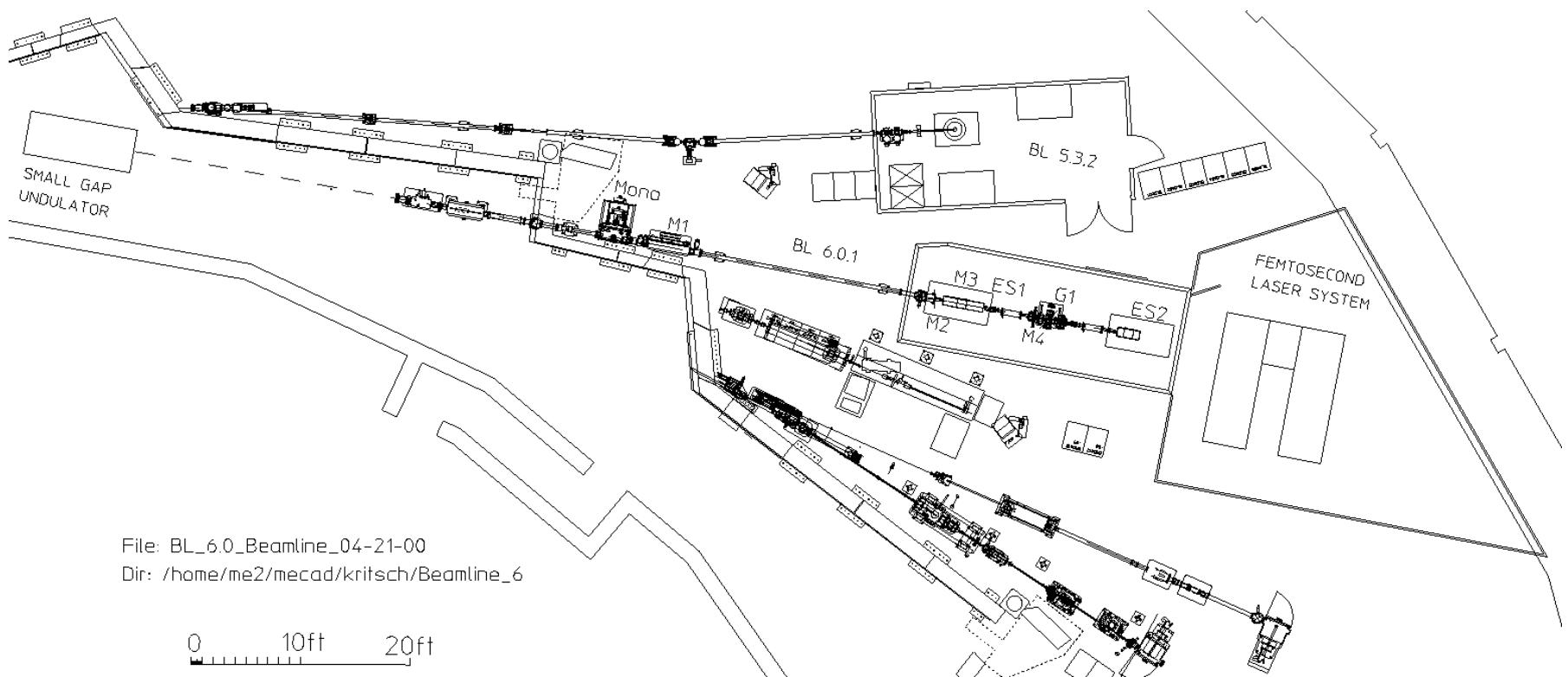
# Possible future developments at beamline 5.3.1



- Imaging detector gateable in 2 ns
- Increasing pulse energy of Falcone laser to 10 mJ
- Microfocusing optics: reduce beam size by 10 times
- Extending crystal monochromator to lower photon energies
- Make dispersive set-up for hard x-rays
- Methods for absolute timing of laser with respect to x-rays
- Improved tunability of laser wavelength



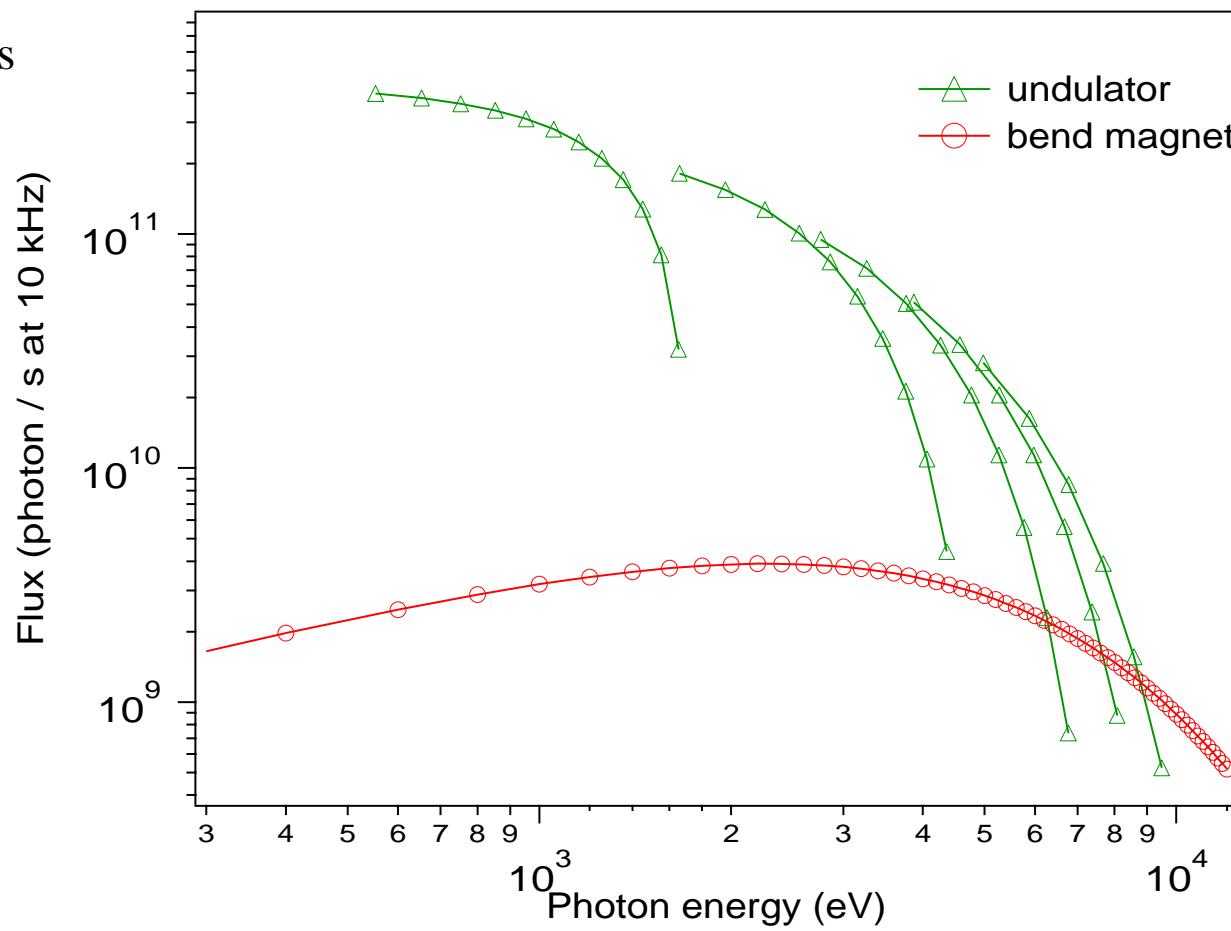
# Proposal for UXS facility, space layout



# Undulator source

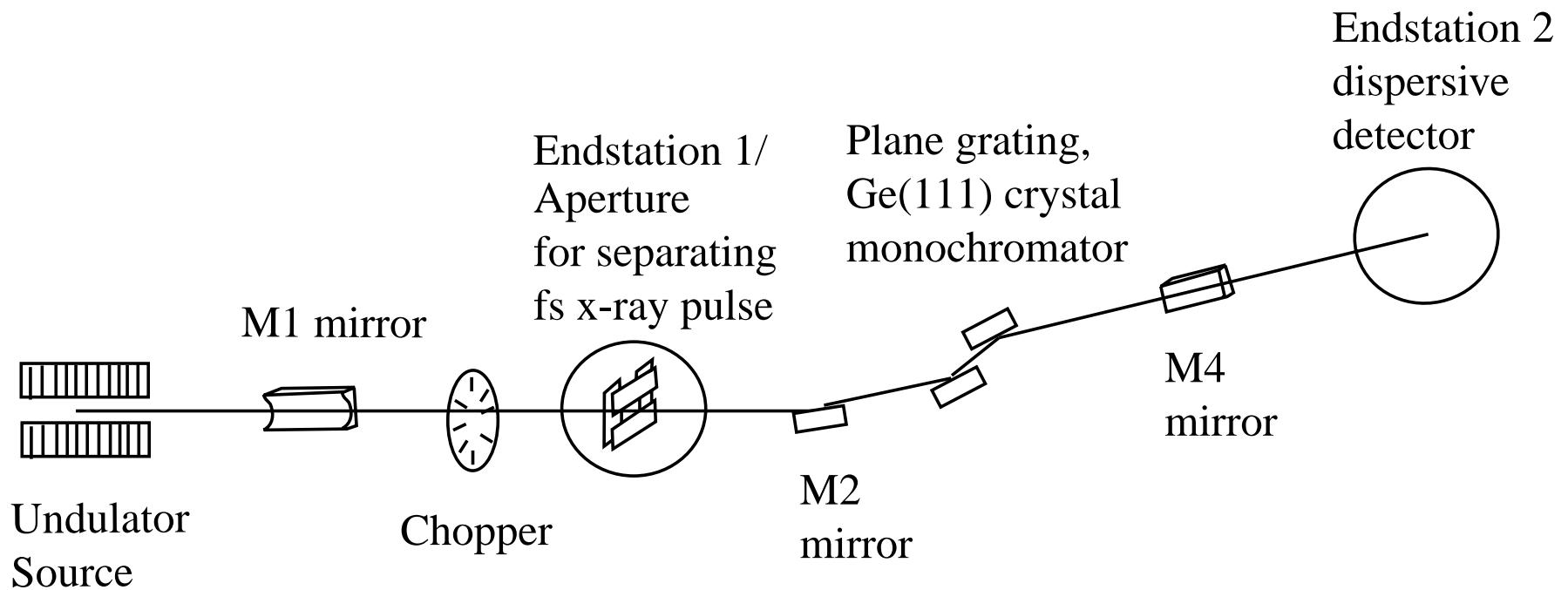
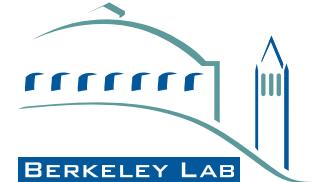
- X-ray undulator at low E ring:  $\lambda_u = 2 \text{ cm}$ , 50 periods, in vacuum
  - Alternative superconducting undulator

In 30 ps pulses



Efficiency factor for fs x-ray pulses  $7 \times 10^{-4}$

# Undulator beamline 6.0 schematic layout



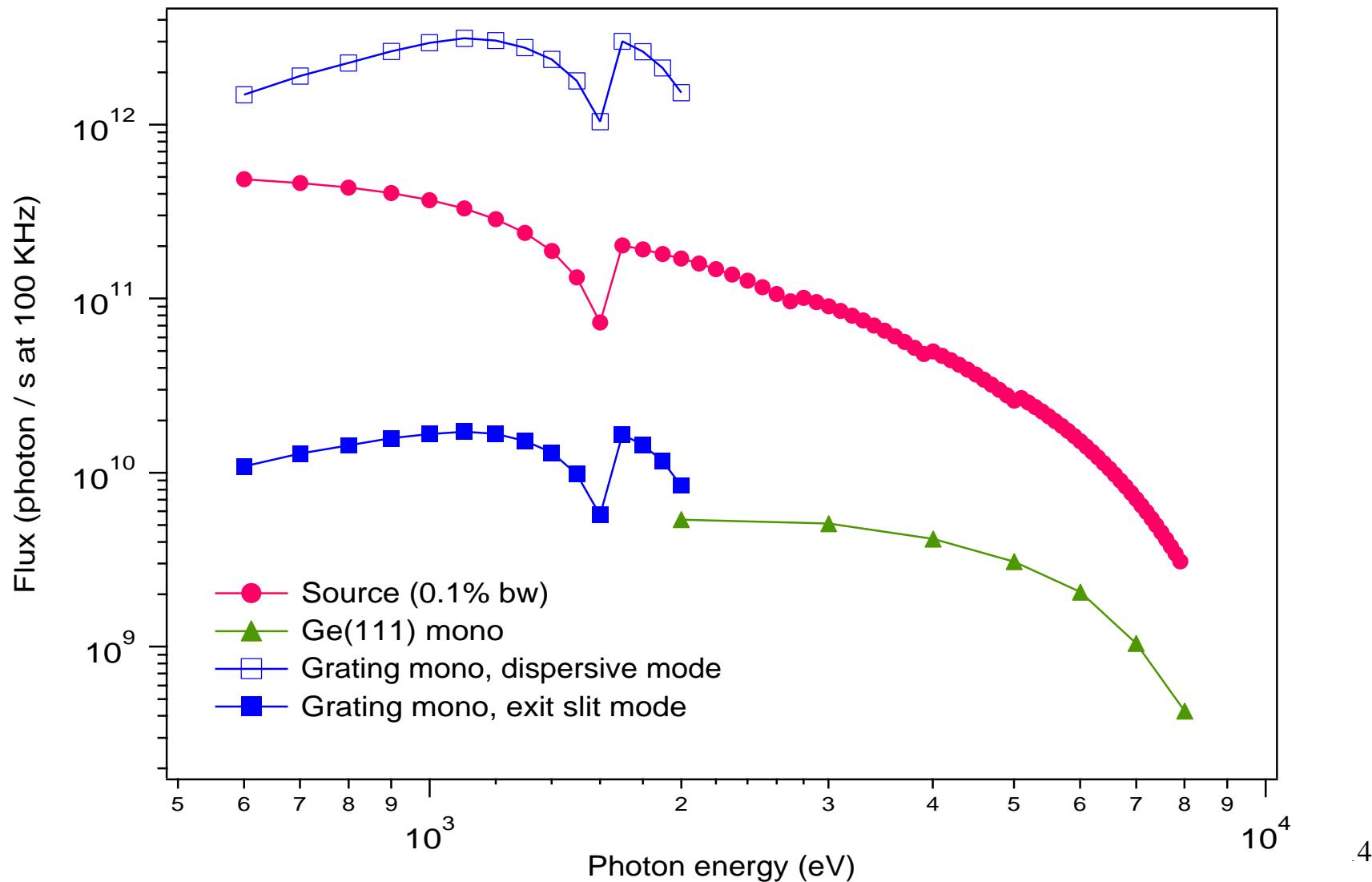


# Optical elements of undulator beamline 6.0

	Type	Coating and blank material	Dimensions (mm)	Radius (m)	Incidence angle(°)	Grating period order
M1	Toroidal mirror	Pt-coated silicon	650 x 65	933 (R) 0.0525 ( $\rho$ )	89.57	-
M2	Cylindrical mirror	Pt-coated silicon	150 x 20	356,462	89.57	-
M3	Plane	Pt-coated silicon	100 x 20	$\infty$	85.8 - 89.1	-
G1	Plane grating	Au-coated silicon	40 x 20	$\infty$	84.5 - 87.5	1/1200, -1
X1, X2	Crystal	Germanium (111)	20 x 20	$\infty$	7 - 70 ( $\theta_B$ )	-
M4	Plane elliptical mirror	Pt-coated silicon	600 x 65	222	89.57	-

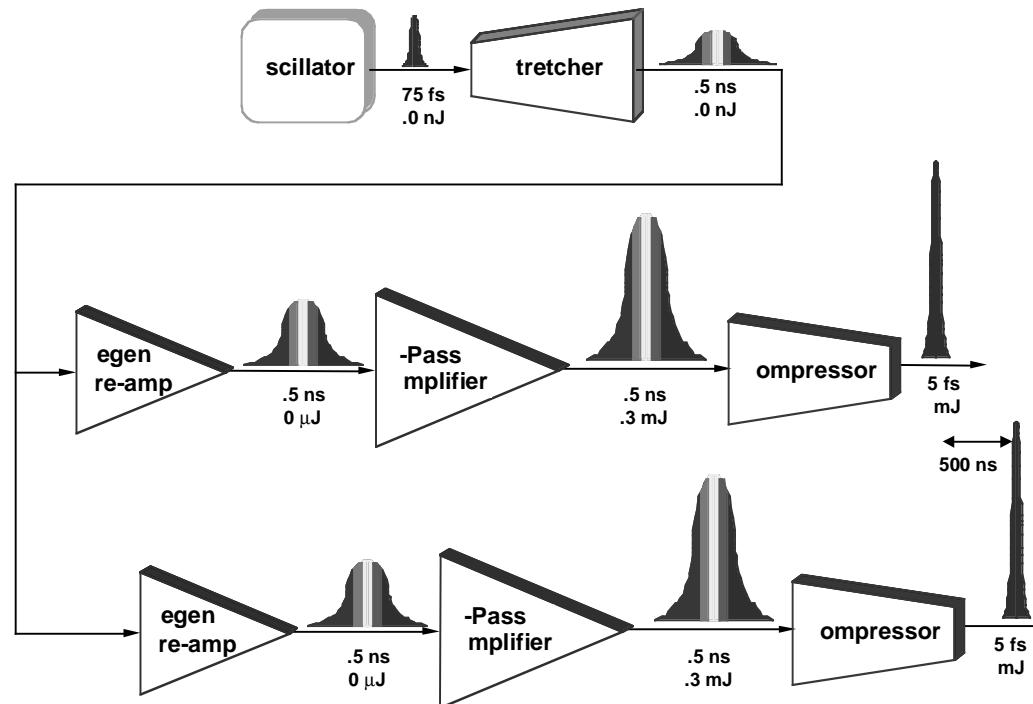


# Calculated flux from undulator beamline 6.0



# Laser system at undulator beamline 6.0

- ~1 mJ pulse energy, 75 fs FWHM, at ~760 nm (in resonance with wiggler 3rd harmonic)
- 100 kHz repetition rate, 100 W average power
- Diffraction limited focusing, beam parameter:  $M^2 < 1.1$  for efficient laser - electron beam modulation
- Built at Lawrence Livermore National Lab





# Characteristics of undulator beamline 6.0

	Undulator BL 6.0	Bend magnet BL 5.3.1
Photon energy range	500 eV - 8 keV	50 eV - 12 keV
Flux ps pulses	$10^{10}$ 1/s	$10^8$ 1/s
Flux fs pulses	$10^7$ 1/s	$10^5$ 1/s
Repetition rate	100 kHz	5 kHz
Photon energy resolving power	3000 crystal 3000 grating	1000 crystal 200 grating
Spot size	30 x 40 μm	100 x 300 μm